



## COLUMBIA GLOBAL ENERGY DIALOGUE

# Low-Carbon Fuels for Aviation and Maritime Transport: Workshops Summary

By **Pierpaolo Cazzola** and **Dr. Colin Murphy**

On February 27, 2023, and March 16, 2023, Columbia University's Center on Global Energy Policy (CGEP) and the Institute of Transportation Studies (ITS) of the University of California, Davis, convened roundtable discussions—the first in New York and the second in Brussels—to discuss options for the decarbonization of aviation and maritime transport. These two sectors are likely to remain dependent on fuels (i.e., molecules rather than electrons as energy carriers), even in an electrifying world, but they will require a shift in the fuel mix to be decarbonized, supplementing improved energy and system efficiency.<sup>1</sup>

The two workshops had the same agenda structure, with initial keynotes on framing conditions for policy action on climate and energy, targeted sessions covering aviation and maritime transport separately, and then a joint policy discussion. The events explored:

- The role of different energy options for the shipping and aviation sectors: common needs and key differences.
- Challenges and opportunities for the deployment of low-carbon fuels in these modes.

This summary reflects the authors' understanding of key points made in the course of the workshops. It does not necessarily represent the views of the Center on Global Energy Policy. The piece may be subject to further revision.

The Center on Global Energy Policy would like to thank Breakthrough Energy for their gift to CGEP in support of research related to low-carbon fuel policy for aviation and maritime transport. More information is available at <https://energypolicy.columbia.edu/about/partners>.



- Policy approaches currently in place to support low-carbon fuels in North America, Europe, and internationally—covering activities of the International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO).
- Policy updates required to accelerate low-carbon fuel deployment, mitigate investment risks, and minimize trans-Atlantic frictions.

The workshops brought together representatives from international organizations, national administrations, aircraft manufacturers, aviation and shipping industry associations, ship owners and operators, engine manufacturers, energy companies and industry associations, classification societies, multilateral development banks, investor entities, think tanks, nongovernmental organizations, and academia. This summary focuses on the main topics covered during the lively discussions at both events.

## Aviation

The first workshop sessions looked at which sustainable aviation fuels (SAFs) are the most viable and credible candidates for a low-carbon future in aviation, especially for long-distance flights. These sessions acknowledged that jet fuel has a unique combination of properties that enable aircraft to safely operate, requiring “drop-in” liquid hydrocarbons with a very similar performance and safety profile but with significantly lower life-cycle emissions. As SAF are unlikely to be cheaper than the fossil benchmark, participants found it difficult to see clear opportunities for a spontaneous transition. Due to this significant challenge, they agreed that policy is necessary to push solutions forward.

## Maritime Transport

The second session focused on maritime transport, where prospects point to a diversity of candidate fuels. Scenarios discussed ranged from cases highly reliant on biofuels to cases with a major uptake of nonbiological fuels, including methanol, ammonia, and synthetic hydrocarbons.<sup>2</sup> Unlike ammonia, producing methanol and other carbon-containing fuels requires a source of carbon, either biomass or large-scale CO<sub>2</sub> capture (itself an energy-intensive process).

Shipping fuels are expected to be primarily used in internal combustion engines. Participants mentioned that engines have been or are being developed to work with different fuels and that new builds of maritime vessels are increasingly expected to be dual-fuel ships.

Participants also noted that shipping has a significant role in transporting energy needed in the rest of the economy: as long as their transport costs are affordable, low-carbon energy carriers needed



for industry and other sectors may end up influencing the choice of fuel used in maritime transport.

Both methanol and ammonia are commonly used industrial chemicals, produced at large scale. Attendees mentioned that, while a shift in their production toward low-carbon pathways would still be necessary, using methanol and/or ammonia as shipping fuels would help create a larger, more liquid, and more resilient market. This would help manage the potential risk of a lack of fuel for the shipping sector. The use of both ammonia and methanol as shipping fuels still comes with regulatory challenges, as there is a need to develop and approve: engines running on these fuels; ship designs enabling their on-board storage; protocols, standards, and infrastructure to safely move and transfer these molecules in ports, when they are used as fuels; and emergency response procedures.

Spillovers from SAF production could also help with the availability of shipping fuels via drop-in hydrocarbons created as by-products of SAF production.

As in the case of aviation, there was consensus among participants about the need for policy action to scale up the availability of low-carbon fuels and narrow the cost gap with the fossil benchmark.

## Cross-Cutting Considerations

Carbon-containing low-carbon fuels for aviation and shipping can be produced from both biogenic and nonbiogenic sources of feedstock. For biogenic, the increase in the sustainable availability of feedstocks is a key challenge for scale-up. For nonbiogenic, which is possible by combining hydrogen from low-carbon sources (primarily renewable electricity) and carbon from direct air capture (DAC), challenges mainly relate to large energy requirements and renewable energy availability limitations.<sup>3</sup>

Biofuel and e-fuel (derived from chemical processes requiring low-carbon electricity as primary energy) technologies are also not mutually exclusive; they can be complementary, since low-carbon electricity and biogenic carbon streams can be part of processes such as power and biomass to liquids.

The aviation and shipping sessions also considered other technologies that add to operational and efficiency improvements and compete with low-carbon fuels to decarbonize these sectors. Participants see batteries as having a role in short-distance and smaller aircraft and ships. Hydrogen is also seen as a concrete possibility in aviation, thanks to its high gravimetric energy density and despite challenges for its on-board storage, but much less so for shipping. Challenges, relevant to both aviation and shipping (and not balanced in marine transport by particular advantages from high gravimetric energy density), relate to leakage, metal embrittlement, the need for an extremely low temperature for storage in liquid form, significantly

lower (by a factor four) volumetric density compared to hydrocarbon fuels, the need for a dedicated and complex refueling infrastructure, and a high-risk profile for the investments required to deploy it.

## Policies

Workshop sessions joining both aviation and maritime transport sectors offered opportunities to outline key developments in policymaking. The focus of these was on Canada, Europe, and the United States. The scope included broad cross-cutting considerations related to the energy transition, as well as deep dives in national and transnational measures in place and under discussion. Participants noted efforts and ongoing discussions within the ICAO and IMO—the international organizations assisting their member governments to establish international regulations for aviation and maritime transport sectors.

## Policy Challenges

Workshop discussions pointed to key areas of action needed to fill existing policy gaps, including:

- The importance of a supportive framework for increased decoupling between aviation and shipping activity (i.e., passenger and freight kilometers) and environmental impacts.
- The importance of adopting a life-cycle approach in the assessment of greenhouse gas emissions from SAF and low-carbon shipping fuels.
- Major differences between the policy approaches adopted in the European Union and in the US/North America, especially in the way they address carbon pricing and subsidies, and a need for convergence.
- Specific aspects related with infrastructure needs.
- Opportunities from actions taken across private sector stakeholders, such as voluntary purchase of low-carbon fuels occurring in the context of sustainable buyer alliances.
- Key milestones and developments needed at ICAO and IMO through the combination of regulatory instruments (such a green fuel standard or carbon intensity mandates, based on life-cycle emission accounting) and funding mechanisms that leverage carbon revenues to support increased investments for the production of low-carbon fuels and an equitable transition across countries.

The policy discussions also looked into the topic of reliable carbon offsets, and in particular the role of credits and DAC investments.



All sessions also paid specific attention to differences (e.g., readiness to pay, availability and cost of capital, and skills availability) across global regions—particularly between developed and emerging economies—and the need for a global developmental agenda that leaves no one behind.

*(Greater details on the discussions developed at these events, further insights on the policy frameworks in place, and an elaboration of specific considerations regarding policy gaps are available in an extended workshop summary on the ITS-Davis website.<sup>4</sup>)*

## Notes

1. If a credible measurement, reporting, and verification framework is developed and if technology progresses, these developments would also complement carbon offsets.
2. Despite near-term relevance, underlined by some participants, liquefied natural gas is not featured in net-zero-compliant scenarios, except for cases considering a switch to bio- or synthetic gas.
3. Notwithstanding the significant renewable electricity potential in specific global geographies, the example of Chile was specifically flagged by some of the participants.
4. Pierpaolo Cazzola and Colin Murphy, “Low-Carbon Fuels for Aviation and Maritime Transport: Insights from Two Mirroring Workshops Held in the US and Europe,” UC Davis European Transport and Energy Research Centre, Institute of Transportation Studies, June 2023, <https://doi.org/10.7922/G2SB442Z>.

## About the Authors

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Pierpaolo authors – as independent researcher – targeted analyses (e.g. for the European Parliament) supporting the European policymaking process. He is also cooperating with the World Bank for the development of policy instruments aiming to manage vehicle emissions in emerging economies.

Prior to the current assignments, Pierpaolo spent more than 20 years working internationally at the intersection of transport, energy and environmental sustainability.



During the year 2022, he was appointed by Minister Enrico Giovannini as an advisor of the Italian Ministry for Infrastructure and Sustainable Mobility, in the context of its “structure for the ecological transition of mobility and infrastructures” (STEMI). This was tasked to elaborate policy recommendations on transport decarbonisation, including in the framework of the implementation of the European Green Deal.

Pierpaolo was advisor on energy, technology and environmental sustainability for the International Transport Forum (2019–2022), transport lead in the Energy Technology Policy Division of the International Energy Agency (2014–2019), coordinator of the Electric Vehicles Initiative of the Clean Energy Ministerial (2016–2019), Secretary of the Working Party on Pollution and Energy of the World Forum for the Harmonization of Vehicle Regulations (WP.29) of the United Nations (2011–2014), fellow at the Institute of Prospective Technological Studies of the Joint Research Centre of the European Commission (2010–2011), analyst on material flows at the Environment Directorate of the Organisation for Economic Cooperation and Development (2010) and transport and energy analyst at the International Energy Agency (2004–2010), where he began his career working on energy balances and CO<sub>2</sub> emission statistics (2001–2004).

Pierpaolo holds a Master in energy economics from the Institut Français du Pétrole et Énergies Nouvelles (IFP School, France, 2001), a Master in Aerospace Engineering from the Politecnico di Torino (Italy, 2000) and a Bachelor of Engineering in Aeronautics from the University of Glasgow (United Kingdom, 1999).

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